REU Site: Characterization of Advanced Materials I
David Bahr, Washington State University, DMR
Award#9876937

- Involved undergraduates in Materials characterization projects for a 10 week program to retain and attract students to materials science
- Provided a summer research experience to 30 students from 13 different schools and 9 different states.

Freshmen to seniors worked on 30 different projects including:

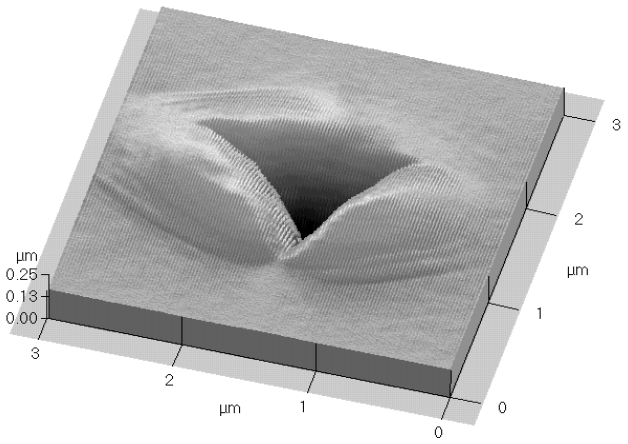
- *Nanoindentation and the effects of hydrogen on deformation*
- *Thin film fracture and oxide characterization*
- *In situ TEM study of PZT crystallization*
- *Metal matrix composites*
- *TEM study of tungsten oxidation*
- *Residual stress in sputtered films*

- 12 Publications or presentations at national conferences with REU students (*) including:

Evolution of Plastic Zone During Nanoindentation, C.L. Woodcock* and D.F. Bahr, Scripta Materialia, 43, pp. 783-788 (2000)

Structural and Mechanical Characteristics of Anodic Oxide Films on Titanium, M. Pang, D.E.Eakins*, M.G. Norton, and D.F. Bahr, Corrosion, 57, pp. 523-531 (2001)

~140 ppm hydrogen



Scanning Probe Image of a nanoindentation into hydrogen charged Beta Ti Alloy, showing cross slip is altered by dissolved hydrogen. Kevin Morasch, WSU REU Program summer 2000.

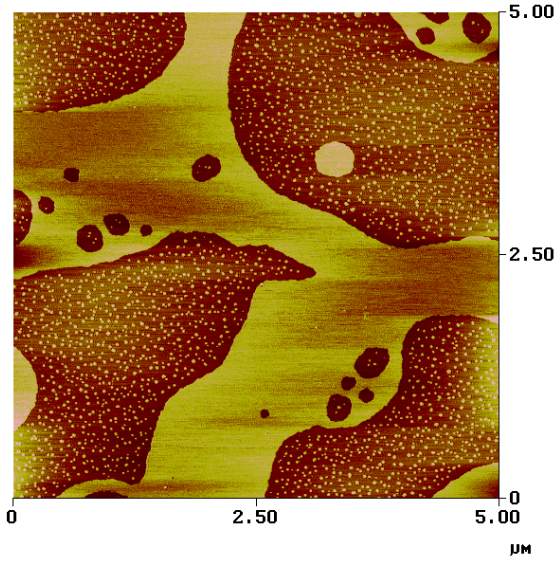
Publications and Presentations by REU Students/Acknowledging NSF-REU Support. (*undergraduate author)

1. Evolution of Plastic Zone During Nanoindentation, C.L. Woodcock* and D.F. Bahr, Scripta Materialia, 43, pp. 783-788 (2000)
2. Effect of Thermal Treatment on Failure Modes in Tungsten Wire, P.P. Bourque*, D.F. Bahr, and M.G. Norton, Materials Science and Engineering A, 298, pp. 73-78 (2001)
3. Phase Transformations in Sol-Gel PZT Thin Films, D.P. Eakin*, M.G. Norton, and D. F. Bahr, in Proceedings of the Materials Research Society, Materials for Novel Oxide Based Electronics, 623, pp. 185-190 (2000)
4. Structural and Mechanical Characteristics of Anodic Oxide Films on Titanium, M. Pang, D.E.Eakins*, M.G. Norton, and D.F. Bahr, Corrosion, vol. 57, pp. 523-531 (2001)
5. Relationship Between Film Chemistry, Structure, and Mechanical Properties in Titanium Oxides, M. Pang, D.E. Eakins*, M.G. Norton, and D.F. Bahr, Proceedings of the Materials Research Society, Structure-Property Relationships of Oxide Surfaces and Interfaces (2001 in press)
6. Plastic Zone Development Around Nanoindentations, C.L. Woodcock*, D.F. Bahr, and N.R. Moody, Proceedings of the Materials Research Society, Fundamentals of Nanoindentation and Nanotribology II, pp. Q7.14.1 – 7.14.6 (2001)
7. The Effects Of Hydrogen On Deformation And Cross Slip In A BCC Titanium Alloy, K.R. Morasch* and D.F. Bahr, Scripta Materialia vol. 45, pp. 839-845 (2001)
8. Processing and Reliability Issues in PLZT and PZNT Thin Films via Sol-Gel, P. Banerjee, D. Bahr and A. Bandyopadhyay, Symposium on Sol-Gel Thin Films, Pacific Coast Regional Meeting of the American Ceramic Society, October 27-29, 1999.
9. Indentation Techniques to Measure the Adhesion of Hard Films on Soft Substrates, D.F. Bahr and A.L. Olson*, TMS 2001 Annual Meeting, General Abstracts Adhesion Symposium (Feb. 2001)
10. Slip Band and Step Formation Around Small Scale Indentations, D.F. Bahr, C.L. Woodcock*, and K.R. Morasch*, Materials Research Society Spring Meeting, Symposium BB, Material Instabilities and Patterning in Metals (April 2001)
11. Micro-Machining of PZT-Based MEMS, T.B. Myers*, S. Bose, J.D. Fraser, and A. Bandyopadhyay, Proceedings of the Innovative Processing and Synthesis of Ceramics, Glasses, and Composites, American Ceramic Society (2001)
12. *Thin Film Fracture During Nanoindentation Of Hard Film – Soft Substrate Systems*
    M. Pang, K.D.Weaver*, and D.F. Bahr, Proceedings of the Materials Research, Thin Films Stresses and Mechanical Properties IX, vol. 695, pp. L7.2.1-6 (2002)

REU Site: Characterization of Advanced Materials II
David Bahr, Washington State University, DMR Award#9876937

Training

- 50% of the participants are women.
- All of the program participants who have graduated are either in graduate school or are in an industry engineering job.
- 5 Freshmen, 7 Sophomores, 14 Juniors, and 4 Seniors were active in the program.
- 30 students participated
- Students used the following characterization methods
    - •Scanning Electron Microscopy
    - •Transmission Electron Microscopy
    - •Nanoindentation
    - •Orientation Imaging Microscopy
    - •Optical Microscopy
    - •FT Infrared Spectroscopy
    - •Auger Electron Spectroscopy
    - •Atomic Force Microscopy
    - •Scanning Tunneling Microscopy
    - •Xray Photoelectron Spectroscopy



AFM image of Non-peripherally substituted Octa-Octyloxy Copper (II) Phalocyanine (**nCuPCO**) spun onto silicon. Tammy Oshiro, WSU REU Program summer 2001

Outreach Activities

Student visits to Pacific Northwest National Laboratories EMSL facility to utilize XPS and Auger systems.

Student and faculty visits to industrial characterization company in Spokane (HiRel Labs).

Visits by faculty to U. New Mexico, Western Washington U., Walla Walla College, Whitworth College, Whitman College, Boise State U., and the U. Idaho to promote the program.

- Our target population for REU program participants was primarily from schools from the Pacific Northwest and Rocky Mountain states that do not have access to the modern instrumentation that is needed for materials research or do not have specific MSE programs. We aimed to provide students, both from institutions with limited research programs as well as students from groups traditionally underrepresented in science and engineering, a 10 week experience that would stimulate their interest in materials science while providing them with technical skills for their future careers. We placed particular emphasis on attracting students from demographic groups traditionally underrepresented in engineering, particularly women. Additionally, we strove to attract students from a variety of majors into materials research, and to reach students of all ages (freshmen to seniors).
- The meters of success include:
- Participants from 13 different schools and from 9 different states.
- Half of the participants are women.
- To date, all of the program participants who have graduated are either in graduate school or are in an industry engineering job working.
- To date, 12 publications or presentations with REU undergraduates (with three more currently in progress from this past summer).
- Students from 8 different majors were represented in the program.
- 5 Freshmen, 7 Sophomores, 14 Juniors, and 4 Seniors were active in the program.
- 1 REU student's poster was a finalist for "Best Poster" at the MRS Fall Meeting 2001 (Christy Woodcock).
- 1 REU student who has since graduated was named "Outstanding M.S. MSE Student" at WSU (Todd Myers).